VR Pet Therapy for Improving the Well-Being of Adults with Autism: A Pilot Study

Siddharthan Karunakaran(✉), Kurtis Weir, Wenge Xu, and Tychonas Michailidis

Birmingham City University, Birmingham B4 7BD, UK
siddharthankarunakaran97@gmail.com
https://www.bcu.ac.uk/research/human-computer-interaction

Abstract. Recognition of autism has significantly increased in the last decade, with concerns on how to effectively support adults with ASD (Autism Spectrum Disorder) as mental health continues to be a struggle needing to be addressed. This paper explores the integration of virtual reality and pet therapy for therapeutic intervention, investigating the feasibility and effectiveness of virtual environments simulating interactions to improve the social and psychological well-being of adults with ASD. To first determine requirements a mixed-methods approach was employed, looking to gather perspectives from both the wider ASD community, as well as NHS specialists through an online survey and in-person discussions. Both groups (ASD n = 14, NHS clinicians n = 9) provided insights to inform the design of a virtual pet simulation, which was followed by final user testing of the VR prototype itself again with an adult with ASD and NHS clinicians. Two test groups were conducted split between clinicians and an ASD "lived experience" adult testing the designed pet simulation, the first group looking at 5 themes; General observations, Applicability of the prototype for therapeutic treatment, Suggestions for improvements, Positive aspects, and Comfort for autism, and the second group looking at; Affection towards the dog, Realism, Excitement and surprise, VR interactions, and Comfort. Both groups provided in-depth comments and recommendations towards viability and overall findings suggested participants formed strong emotional connections with virtual pets in virtual safe controlled spaces. A set of recommendations is provided for future designers in the pursuit of more accessible environments for ASD users.

Keywords: VR · Virtual Reality · Pet Therapy · Autism · ASD

1 Introduction

The prevalence of autism has significantly risen in the last decade [27,36], which can be attributed to multiple factors such as increased global awareness, changes

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in definition and diagnosis, or improved identification in under-represented populations via sex, geography, or race/ethnicity [42]. Within the UK data suggests that autism affects 1–2% of the population, or 1 in 100 children or 2 in 100 adults [12], however it is estimated that a significant portion of the population is still undiagnosed and that truer estimates could exceed 1.2 million, or roughly 2.2% of the population [31].

With numbers rising there is an increasing need for effective support and treatment for autistic people. Although increasingly complex, symptoms of ASD (Autism Spectrum Disorder) include impaired non-verbal communications such as eye-to-eye gaze, facial expressions, gestures, repetitive behaviours, and a loss of interest in social functions, communications, and activities [33], although the severity of symptoms can differ significantly [13]. Outside of these core characteristics, there are many studies that highlight a link between autism and comorbid conditions, such as OCD (Obsessive-Compulsive Disorder) [28], ADHD (Attention Deficit Hyperactivity Disorder) [22], epilepsy [2], or higher rates of mental health issues such as depression [17]. For children it is reported that approximately 75% also experience other medical conditions such as anxiety, bipolar disorder, or sensory issues, further increasing treatment costs and caregiver demands for families [33].

Treatments for ASD are challenging, behavioural therapies like CBT (Cognitive Behavioural Therapy) are time-consuming and typically require years of treatment provided by trained professionals [23]. Even so, reported benefits are not applicable to all ASD people due to the challenges faced in understanding CBT and applying techniques to daily routine and life [41]. Medication may be prescribed for comorbid disorders tied to ASD, but not existing for the core underlining issues, and when used there are high risks of side effects. There is a lack of research on the effectiveness of interventions in adults with ASD [41] that aim to reduce these comorbid problems, and that the ASD adult population is highly understudied [11], even with rising awareness of mental health.

1.1 Motivations and Rationale

Discussions with NHS (National Health Service) professionals revealed that there are less services available for adults with autism within the UK, and that their local trust were pioneering the first Autism Mental Health Intensive Support Team within their sector. The team specialises in providing services and support for adults with complex cases of autism and mental health issues, pooling from the experience of several clinical specialists. Their team's findings revealed that current methods for supporting with autism were outdated, many services focused primarily on children but dropped support into adulthood, and that new solutions for effective care are necessary. One such investigation showed an overwhelmingly positive reaction to pets from their adult ASD service users, however, due to their complex situations many of their users did not have access to animals due to a range of reasons, such as economic or financial barriers, restrictions within buildings from both home or service buildings, or for health

& safety concerns of both the users and the animals that prohibited access, something that mirrors concerns in previous research [7].

As a benefit from pet therapy solutions was established, alternative solutions towards providing these benefits without the need for a real animal were investigated. Within the ever improving field of virtual reality (VR) the latest available headsets provide increased levels of immersion through enhanced resolutions, interactions, and environmental processing techniques compared to older devices, as well as becoming wireless, more affordable, and thus more applicable towards health care purposes. To reach this goal a virtual reality pet therapy simulation was created and prototyped to determine the suitability of such an approach.

2 Literature Review

2.1 Pet Therapy and Autism

Animal Assisted Therapy (AAT) is described as a health intervention aimed to improve physical, emotional, social, or cognitive functioning, with animals used as part of the treatment process [1]. The International Association of Human-Animal Interaction Organisation (IAHAIO) highlights that only domesticated animals, such as dogs, horses, cats, guinea pigs, rats, fish, and birds can be involved in interventions [18].

Dogs and humans have a long-standing semiotic relationship, which involves a unique way of communicating through gestures, body language, and other forms of non-verbal communication [24], with dogs having a flexible repertoire of visual, acoustic, and olfactory signals [34].

In a case study [35], a nine-year-old girl with autism who had difficulty interacting with classmates at school and with her sisters, exhibited significant improvements after four sessions with therapy dogs. She was able to learn and effectively use simple commands like ‘speak’ while gesturing her index finger to make her dog bark. She was also able to interact with a unfamiliar girl in the park by teaching her the command, demonstrating confidence in interacting with strangers and improvisation in mentoring a peer.

Solomon [35] proposes that these improvements could be linked to several reasons, such as the interactions between dogs and children being non-linguistic, where speech is not a pre-requisite, instead relying more on gestures and body language making these interactions more accessible to children with ASD [3,4]. Additionally the repetitive and structured antrue of these interactions due to the highly predictable nature of dogs allows the children to anticipate their next move, reducing anxiety and improving social competence, such as a dog triggering play by getting the owner’s attention, jump-starting their next action [16,35].

Another study supports these findings [38], exploring the effects and working mechanisms of dog-assisted therapy in adults. 6 adults with high-functioning autism took part in therapy sessions involving activities such as guiding a dog through obstacle courses and dog petting. Results showed significant improvements in participants' body posture, indicating an increase in confidence. Dogs responded better when greater levels of confidence and improved posture was exhibited, and as a result could have lead to increased self-confidence and self-esteem when this was observed.

2.2 Stress in Adults with ASD

A study investigating psychiatric comorbidity of adults with autism reported that 77% of their 63 participants suffered with major depressive disorder (MDD), 68% with ADHD, and 59% with an anxiety disorder. Previous studies also support MDD being one of the most common disorders referred to adults with ASD [14,32]. Furthermore, stress leads to the severity of ASD traits, hindering an individuals' ability to interact and communicate socially [15]. A study explored the effects of dog-assisted therapy on perceived stress [39] with a sample size of 27 adults. Over 10 weekly sessions findings showed a significant decrease in perceived stress levels utilising the Perceived Stress Scale (PSS) as well as improved social responsiveness. Their adherence to the therapy was also high (98%), which could imply their willingness to attend it was heightened over the 10 weeks. This aligns with an earlier study that showed that salivary cortisol, a hormone in saliva that measures the body's stress response, decreased in children with ASD after service dog interventions. Such studies show promising results in dogs helping to improve stress-related comorbid issues.

2.3 Virtual Reality for Therapy

VR technology today allows a user to look through a head-mounted display (HMD) to perceive a computer generated world, often to unify realistic reality with an artificial one [6,37]. Traditionally virtual reality has been seen to mean any computer-generated three-dimensional (3D) simulation consisting of images, video, and sounds, which would include traditional video games displayed on a TV or monitor. In the last decade, researchers have studied various VR treatment methods utilising several VR technologies for the benefit of individuals with ASD.

Research [19] has investigated the effects of Virtual Reality-Social Cognition Training (VR-SCT) on 8 adults with high functioning autism using Second Life, a 3D virtual massively multiplayer online (MMO) game run on a Windows PC. Results indicated noticeable improvements in the theory of mind and emotion recognition, but are limited due to the smaller sample size.

Another study explored the integration of Dolphin-Assisted Therapy using a virtual environment to improve non-verbal communication of children with ASD. Virtual elements were created using a spherical 320° environment utilising 5 projectors, similar to a CAVE (Cave Automatic Virtual Environment) setup. 15 children were asked to wear 3D glasses assuming the role of a dolphin trainer, with results suggesting more than half were overwhelmed by the experience as well as issues arising regarding glasses fits, designed for adults and impacting sensory stimulation. The sensory requirements of participants is crucial for consideration when attempting to virtualise elements, as well as appropriate adjustments of any head gear.

Studies also evaluated the integration of CBT and gradual exposure within a VR environment [25,26] and its effects on the fears and phobias of adults and children with ASD. Interventions were delivered in a 'Blue Room', a seamless 360° room that replicated real-life scenarios that caused fears and phobias. Findings of both studies showed improvements in the ability to tackle phobias, prolonging after the intervention. However, this study and the previously mentioned utilised various digital or simulated methods that could be improved upon with a VR-HMD.

Comparatively there is limited research around VR headsets for autism as a tool for therapy, possibly due to these technologies being newer, or other potential issues, such as the sensory requirements in wearing an enclosed headset. Another study did look at the willingness of VR-HMDs and possible negative side effects for 30 participants with ASD. Results showed that participants were willing to complete the presented scenarios, as well as suggesting that there were minimal negative effects while wearing the headset.

There have been works towards investigating the effects of VR and MR (Mixed Reality) headsets in more general mental health contexts outside of ASD, such as a study looking at virtual cats in improving mental stress management [29]. Results from 30 students wearing a Microsoft Hololens showed that a virtualised cat interaction significantly reduced mental stress and increased positive emotions, particularly when the cat provided audiovisual feedback. Interestingly participants exhibited a higher willingness for self-disclosure with virtual cats compared to virtual humans, which could be applicable for people with autism due to lower social pressures.

3 Methodology

To test the suitability of a VR pet therapy application for adults with autism, feedback was gathered and inputted from both NHS clinicians as well as ASD individuals.

This experimental study employs a mixed method approach, consisting predominantly of qualitative data. The study was conducted in two phases (see Fig). The first phase was a preliminary study that gathered perspectives from NHS clinicians ($N = 6$) as well as online survey feedback from ASD communities ($N = 14$), following up with the second phase of testing with a developed prototype. This prototype test included two distinct user groups [39] Group 1: Participants with ASD ($n = 1$) and Group 2: Clinicians ($n = 9$), each providing complimentary perspectives.

3.1 Initial Meeting with NHS Clinicians

As part of the preliminary study, a meeting was held with NHS clinicians which offered expert insights into the lived experiences of autistic individuals. They highlighted the significant challenges faced by adults with autism in a hospital setting and how their mental health can deteriorate due to unpleasant sensory stimuli, therefore resulting in high levels of stress. This emphasized the need for a safe, low-stimuli environment within the VR prototype. The clinicians also noted that many of their autistic patients often form strong connections with animals and engage better in the presence of animals.

3.2 Online Survey

An online survey was conducted with 14 adults (64% Female) with ASD aged between 19 and 44, posted on community pages for ASD.

Pet Ownership: Among respondents, 70% owned a pet and 78% reported a positive attitude towards dogs, which could indicate that dogs might not have a negative impact on stress.

Stress: The Perceived Stress Scale [10] was also administered to identify the stress levels of respondents with ASD [40]. 50% reported high stress, 35.7% moderate stress and only 14.3% indicated low stress levels, aligning with the findings of Joshi et al. (2013).

Sensory Overload: 50% reported that the main reason for stress is sensory overloads such as loud noises (33%), bright flashing lights (20%), visual clutter (18%), vibrations (13%) and the rest answered 'other category' which consisted of answers such as strong smells and tactile sensitivities, indicating that these triggers could be unique to each person. These results further emphasized the importance of avoiding these triggers in the VR prototype.

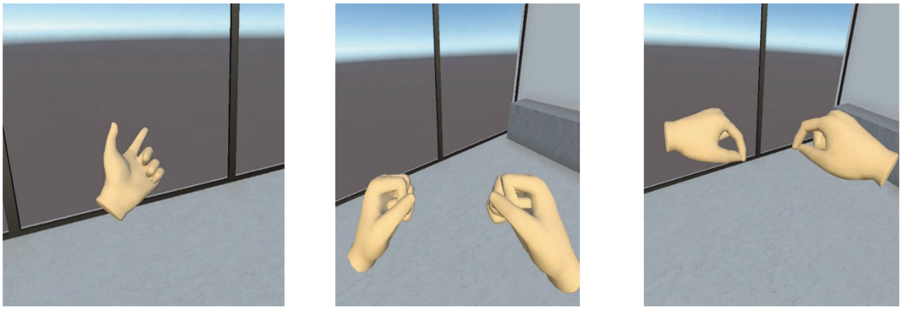
Stress Management: Participants were asked how they manage stress, with the option to choose multiple techniques. The most common method was listening to music, as reported by 9 participants (64.3%), followed by spending time with pets (7 participants, 50%) and engaging in hobbies (6 participants, 42.9%). Other strategies included physical exercises, using technology and stress relief tools, each chosen by 4 participants (28.6%), while 3 participants (21.4%) indicated other methods.

Safe Space: 71.4% reported *'My room'* as their safe space. Similar responses such as *'Home'*, and *'My apartment'* were observed. This could be interpreted in a way that they consider a space safe if it is personal to them and it has the element of familiarity.

Willingness to Use VR-HMD: A 5-point Likert scale was used to measure the willingness of adults with ASD to use VR-HMD as a therapeutic intervention. The most common response was positive with 43% expressing their willingness to use VR-HMD as a therapeutic intervention. However, 29% of the participants remained neutral, reflecting uncertainty. Additionally, 28% either disagreed or strongly disagreed. It could be a result of cyber sickness as some of the participants who had prior experience with VR mentioned experiencing motion sickness and headaches. This highlighted the importance of designing the prototype with measures to reduce cybersickness [20].

3.3 The Prototype

With the insights from the preliminary study acting as the guiding framework, the prototype was designed and developed using Unity, a game development engine. Meta Quest 2 and Meta Quest 3 (VR-HMD) were used as the devices to test the prototype. The prototype featured hand gestures such as ‘Pointing’, ‘Pinching’, and ‘Making a fist’ which would be activated based on user inputs from the controllers (see Fig. 1).



(a) Pointing (b) Making a fist (c) Pinching

Fig. 1. Hand gestures used in the prototype via motion controllers.

Movement in the virtual environment has been enabled using two methods: Continuous Locomotion and Instant Locomotion (Teleportation). Continuous Locomotion allows users to move at a constant pace, however, it can result in motion sickness. Thus, the speed of the Continuous locomotion was reduced after pilot testing and was set at a value of 0.6. In addition, Instant Locomotion (teleportation) was also added to allow the users teleport from one point to the other. According to results from Buttussi’s study [8], teleportation compared to continuous movement methods result in less nausea and are regarded as the safest locomotion method [9]. The VR environment was designed with a minimalist approach to avoid any sensory triggers. Soft and consistent lighting were used instead of any flashing effects, loud and abrupt sounds were avoided, and the visual design followed simple and clear patterns, reducing unnecessary movement and clutter. Various natural elements such as grass lawn, trees, rocks and a clear sky were present, aiming to create a calm and serene environment. The prototype included three dog breeds (Pug, Border collie, and Husky) for the users to choose from, each representing different sizes of dogs.

The interactions between the user and the pet were directly influenced by literature [35,38] and the preliminary study.

Feeding: Many participants mentioned feeding as a key interaction with their pets. This guided the inclusion of a feeding interaction in the prototype, allowing users to virtually feed the dog. Various food objects such as chicken, a slice of watermelon, a loaf of bread, and a slice of apple were added. These food objects would respawn once the users feed the dog, allowing repetition (see Fig. 2a).

Petting: Affectionate interactions such as petting and cuddling, were also frequently mentioned. Hence, the prototype includes a petting feature. When the user touches the pet, they will receive mild haptic feedback, played in intervals through the hand controllers. This enables the users to interact with the dog through touch (see Fig. 2b).

Dog Walking: Several responses emphasized activities like going on walks and runs with their pets. To reflect this, the prototype included a feature where users can call the dog to walk towards them (see Fig. 2c).

(a) Feeding (b) Petting (c) Follow

Fig. 2. Feeding, petting, and 'follow' dog interactions.

(a) Sit (b) Lay (c) Jump

Fig. 3. Sit, lay, and jump gesture-based interactions.

Interactive Commands: Based on the case study of Solomon [35], the following interactions based on the user's hand gestures, were added. **Sit:** When the user presses either one of the trigger buttons, the dog will sit (see Fig. 3a). **Lay:** On pressing both the trigger buttons simultaneously, the dog will lay down (see Fig. 3b) **Jump and bark:** When the user presses the right-hand controller's trigger button and grip button together twice in quick succession (double press), the dog will jump and a barking audio clip will be played (see Fig. 3c).

These interactions were designed to mimic real-life hand gestures such as pointing a finger at the floor (sit), pointing a finger of both hands at the floor (lay), and making a fist twice in quick succession to call someone (call the dog). The aim is to teach non-verbal communication and to help adults with ASD understand non-verbal cues.

3.4 Participants

The study included two participant groups: an individual with autism (N = 1) and NHS clinicians (N = 9). The participant with autism was a 27-year-old female dog owner, who also had ADHD, a common comorbidity of autism. They had prior experience with VR games and met the inclusion criteria of being aged 18–40, diagnosed with autism, and willing to use a VR-HMD. The exclusion criteria included individuals with severe sensory issues, dog allergies or aversions [41]. The second group consisted of nine clinicians (n = 9) who were affiliated with the NHS between the ages 25 and 56 (7 females, 2 males; Mean = 41.89. S.D = 11.05) from specialist fields including clinical psychology, occupational therapy, nursing, and speech and language support. Six of them interacted with autistic individuals daily, typically for over 30 min. Seven of them owned pets (dogs, cats or a gerbil). Most of them had minimal experience with VR-HMD.

3.5 Procedure

The study took place in two locations. The participant with autism was tested in one of the classrooms of Birmingham City University, while the clinicians participated in NHS conference room (4 m x 4.5 m approx.). In both cases, a Meta Quest VR-HMD (Quest 2 for the participant with autism and Quest 3 for the clinicians) was wirelessly connected to a Lenovo Legion 5 laptop which was connected to external displays via HDMI for streaming live visuals from the headset.

Both groups were debriefed about the VR-HMD and its features, provided with an information sheet about the project and a consent form. The VR prototype was then demonstrated after which the participants engaged various tasks. During the sessions, verbal feedback and behaviours of the participants were observed and documented.

After the session, a Cyber Sickness in Virtual Reality Questionnaire (CSQ-VR) [20] was administered followed by a semi-structured interview which was conducted for the participant with autism. For the clinicians, a Focus Group discussion was conducted followed by a post-test questionnaire.

3.6 Data Collection

Qualitative data was prioritized due to the study's exploratory nature and small sample size.

For the participant with autism, an online survey was administered as the part of the pre-test. During the testing session, behavioural observation was utilized to capture the participant's verbal initiations and non-verbal cues (e.g., smiles, fidgeting with the VR-HMD and body language) [41]. Post-test, the CSQ-VR was used to measure if the participant experienced any motion sickness and dizziness. Additionally, a semi-structured interview consisting of 27 open-ended questions was conducted to capture the participant's experience and gather insights. Data was collected through written notes and voice recordings, which was transcribed for further analysis.

For the NHS clinicians, data collection through the focus group discussion was voice-recorded along with observational notes during the VR session. Following the session, participants completed an online post-test questionnaire using Microsoft Forms, capturing age, gender, job role, years of experience, frequency and duration of interactions between them and individuals with ASD, pet ownership, VR familiarity, a System Usability Scale (SUS), perceived satisfaction and effectiveness rating, and willingness to adopt VR pet therapy as a therapeutic intervention.

4 Results and Discussion

4.1 System Usability Scale (SUS)

The System Usability Scale (SUS) [5] was administered to assess the usability of the VR Pet Therapy Prototype from the perspective of the clinicians who

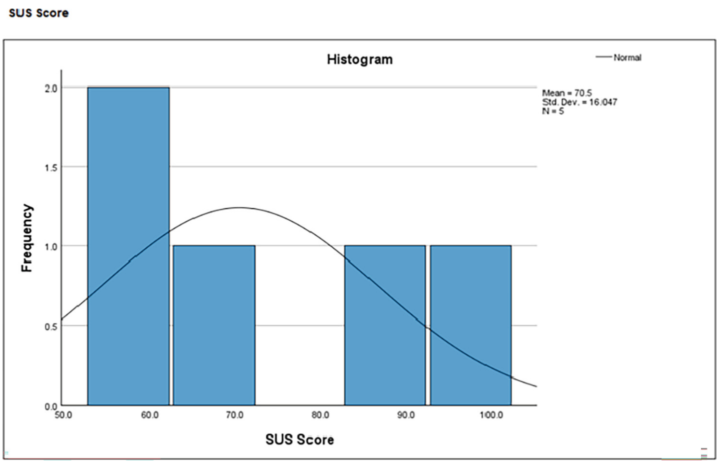


Fig. 4. Histogram of SUS score showing an averaged score of 70.5.

volunteered to test the prototype (N = 5). It consists of 10 statements that participants rate on a 5-point Likert scale, ranging from "Strongly Disagree" to "Strongly Agree", yielding a score between 0 and 100. The prototype achieved an overall score of 70.5 (see Fig. 4). Systems with a SUS Score of above 68 are considered as "Good" in terms of usability.

4.2 CyberSickness Questionnaire (CSQ-VR)

The results from the CSQ-VR [20] (see Table 1) indicate that the participant experienced minimal symptoms across the three categories: Nausea, Vestibular, and Oculomotor. Considering the baseline score being 6 and the maximum possible score 42, the prototype's overall CSQ-VR score of 7, reflects a low level of cybersickness experienced by the participant with autism.

Table 1. Table showing the score of CSQ-VR

Category	Symptom	Symptom intensity	Category score
Nausea	Nausea (Nausea A)	1	3
	Dizziness (Nausea B)	2	
Vestibular	Disorientation (Vestibular A)	1	2
	Imbalance (Vestibular B)	1	
Oculomotor	Fatigue (Oculomotor A)	1	2
	Discomfort (Oculomotor B)	1	
CSQ-VR Score = 7			

4.3 User Satisfaction

Clinicians who tested the prototype (N = 5) rated their satisfaction with the VR prototype on a scale of 1 (Not Satisfied) to 5 (Very Satisfied). The average rating was 4.4 out of 5. Three of them rated their satisfaction at Level 5, one clinician rated it at Level 4 and one rated it at Level 3. No clinicians rated their satisfaction at Level 2 or Level 1. These results indicate a high-level of user satisfaction with the prototype.

4.4 Perceived Effectiveness of VR Pet Therapy in Creating a Safe Space

The Clinicians (N = 9) also rated the VR pet therapy prototype's perceived effectiveness in creating a safe space for autistic individuals on a scale of 1 (Not Effective) to 5 (Very Effective). The average effectiveness rating was 4.67 out of 5. Out of the nine clinicians, six clinicians rated the effectiveness at Level 5 and 3 participants rated the effectiveness at Level 4, with no lower ratings.

These results suggest that the majority of the clinicians believe that the VR Pet Therapy could be highly effective in creating a safe and supportive environment for individuals with autism.

4.5 Willingness to Use VR as a Therapeutic Intervention

The willingness of the Clinicians to use VR as a therapeutic intervention was also measured on a 5-point Likert scale. Five participants selected ‘Strongly agree’, three chose “Agree”, one remained ‘Neutral’ and none of them chose disagree or strongly disagree. These results indicate a generally positive attitude toward the use of VR as a therapeutic tool.

4.6 Behavioural Observations and Thematic Insights

The documented data such as behavioral observations, voice recordings, screen captures of the VR session, semi-structured interview, and Focus Group Discussions were carefully reviewed and a thematic analysis was performed for each group separately. Following the data collection of the tested prototype, several areas for discussion are noted.

Emotional Connection and Therapeutic Potential: Results from the participant with ASD showed a strong emotional connection towards the virtual dog, however, this may be influenced by a strong connection to dogs already as a dog owner themselves. Nevertheless, the participant’s reactions and clinician remarks on how a pet can offer an emotional bond and sense of security align, suggesting that the VR prototype successfully simulates a pet-like presence that can foster emotional connections, aligning with previous research [35,40] on how people with ASD often form strong bonds with animals. The participant’s self-reflection on their emotions after trying the prototype demonstrated happiness, linking to the clinician’s remarks on the potential of VR as a tool for emotional regulation for ASD. Overall early findings suggest the potential for triggering positive emotions.

Vocalization and Immersion: Despite no vocal functionality within the prototype, both groups attempted to give verbal commands alongside attempted gestures, suggesting a good level of immersion but also providing insight into the importance of this feature. Both groups suggested voice commands should trigger responses from the virtual dog (e.g. ‘sit’, ‘jump’, ‘come here’). This correlates with previous research where the immersive nature of VR can replicate real-world interactions [25,30]. While aware of the virtual nature of the dog, the environment was compelling enough to maintain engagement.

Usability and Learning Curve: Both groups experienced difficulties with performing certain gesture interactions, indicating a required learning curve with the VR controllers and additional redesigns of interactions. No on-boarding was present within the application so it is likely that integrated tutorials and or demonstrations are necessary during initial learning stages. Additionally clear visual indicators of object locations for additional accessibility are needed, as tracking of the dog and locational awareness wasn't always achieved. Although vibrations were expressed positively, sensory sensitivity to vibrations is a concern. A user that is physically limited, such as in a wheelchair, was also raised as a concern in how they might struggle with some of the interactions. Overall it was evident that a level of customisation and personalisation is required.

Comfort: Comfort was not reported as a problem during testing, but raised as a concern within discussions depending on the sensory requirements of the individual. Self adjustments of the headset (Quest 2) with the participant with ASD was initially difficult and fidgeting stopped once the researcher assisted with adjusting the fit. CSQ-VR scores were low, suggesting minimal levels of cybersickness across both groups, although one symptom was slightly higher reported which was dizziness, which ways to reduce this should be considered (e.g. higher frame-rate, headset adjustments).

Visual Feedback: Both groups expressed a desire for better visual reactions from the virtual dog, where a unresponsive dog would create a disconnection from immersion. According to research [21], immediate and clear feedback from animals is key to improving low self-esteem as it can lead to anxiety and depression.

Physical Boundaries: Physical space was important as well, as clinicians were concerned about the play space, highlighting the impact a potential patient's limited space may have on successful interventions. Having one's sight blocked of the real world can cause anxiety if they are worried about hitting something or falling over, possibly suggesting integration of mixed reality features or ensuring safety measures are part of the experience.

Environmental Design: Clinicians appreciated the natural environment and subtlety of assets, as well as keeping a soft colour palette. The importance of outdoor environments was highlighted, particularly for clinical buildings which can be very monotone. Emphasis on a detailed pet in contrast to a minimalist environment was discussed as important.

Therapeutic Applicability: Another common theme between groups was routine management. The participant commented on how they conditioned their dog to fall asleep to music, which triggers tiredness in themselves once seeing their dog sleeping and listening to the music as well. This aligned with suggestions from clinicians to include day and night cycles, and to represent the end of sessions by returning the dog to a sleeping basket. This could enhance a sense of companionship while reinforcing positive habits.

Positive emotions were displayed in response to displayed dog behaviours, such as subtle ear twitching animations, jumping, and barking, again reinforcing an immersive environment can trigger positive emotions. Clinicians also emphasised the 'escapism' that comes from such a setup, allowing a user to reduce their anxiety and discomfort when in a uncomfortable situation or environment (e.g. hospitals and crowded rooms). The participant with ASD also commented that this type of therapy could benefit adults in respite care.

5 Conclusion

This pilot study aimed to explore VR as a method for delivering pet therapeutic techniques for adults with autism. Through the initial data collection, development, and testing of a VR prototype, the feasibility, acceptance, and potential benefits of virtualising pet therapy were highlighted.

Findings suggest there is promising potential for VR pet therapy as a therapeutic tool for adults with ASD, as well as research suggesting children would also benefit. Strong emotional connections were demonstrated from the participant with ASD when interacting with the virtual pet, with positive verbal and non-verbal feedback indicating a high level of engagement. Clinicians involved in this study also recognised the benefits of this approach and are looking to collaborate further to eventually deploy a similar approach as part of their service.

To conclude, this study provides an initial exploration into the integration of pet therapy, and promising results suggest that with further refinement applying what was learned, VR pet therapy could become a valuable tool for supporting the well-being of adults with ASD.

6 Limitations and Future Works

Despite positive reactions from this initial pilot study, it serves as only a starting point as there are a number of barriers to consider. This research was only able to work with a limited sample size of both respondents and application testers, requiring a larger range of adults with ASD, particularly as each individual can have a vastly different set of requirements. Additionally therapeutic interventions require a great deal of time to conduct and their effectiveness may vary over a long period of time, something that cannot be replicated within a day. There is a potential for bias as the participant tested was both fond of dogs and also had prior experience with VR, possibly influencing reporting. Additionally this study focused primarily on qualitative data and self reporting from verbal testimonies, but additional research is required to compare quantitatively the benefits between this and existing therapeutic methods.

For future works we aim to incorporate suggestions raised by both groups in enhancing the realism and responsiveness of the dog. A longitudinal study should be explored to better evaluate and validate the suitability of this approach for clinical settings, as well as for home use. Additional coverage of a much larger sample size of ASD individuals should be conducted. The integration of voice commands is planned to be incorporated to create a better level of interactivity and thus immersion and engagement for users. This research plans to continue alongside the support of NHS specialists to best optimise improvements for adults with autism.

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